BioMedical Admissions Test   4500/12

Wednesday 2 November 2016   **30 minutes**

SECTION 2   **Scientific Knowledge and Applications**

Instructions to Candidates

Please read this page carefully, but do not open the question paper until you are told that you may do so.

This paper is Section 2 of 3. Your supervisor will collect this question paper and answer sheet before giving out Section 3.

A separate answer sheet is provided for this section. Please check you have one. You also require a soft pencil and an eraser.

Please complete the answer sheet with your:

- BMAT candidate number
- Centre number
- Date of birth
- Name

Speed as well as accuracy is important in this section. ***Work quickly, or you may not finish the paper.*** There are no penalties for incorrect responses, only marks for correct answers, so you should attempt all 27 questions. Each question is worth one mark.

Answer on the sheet provided. Questions ask you to show your choice between options by shading a circle. If you make a mistake, erase thoroughly and try again.

Any rough work should be done on this question paper.
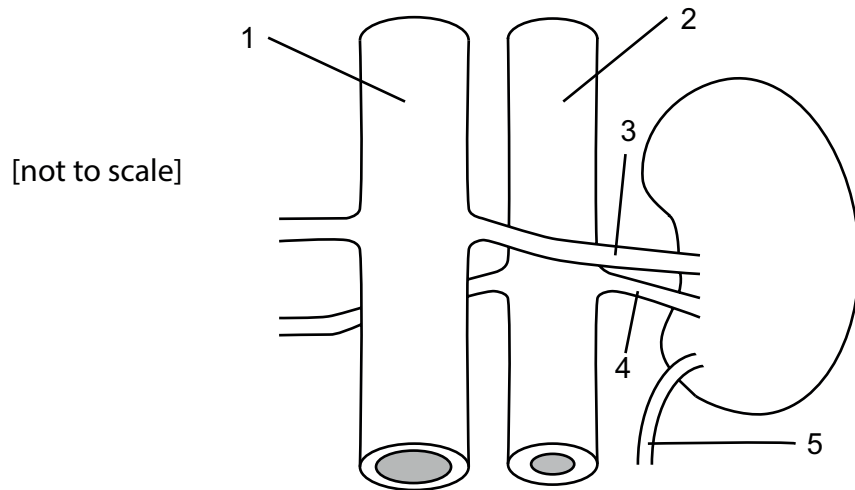
Calculators are NOT permitted.

Please wait to be told you may begin before turning this page.

This paper consists of 20 printed pages and 4 blank pages.

All questions in this paper assume knowledge that is currently on the BMAT specification.

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1 The diagram shows a kidney and its associated vessels from a healthy individual.

[not to scale]

Which row correctly identifies the vessels along with the concentration of urea they contain?

	lowest concentration of urea	*highest concentration of urea*
A	1 is the aorta	2 is the vena cava
B	1 is the vena cava	2 is the aorta
C	3 is the renal artery	5 is the urethra
D	3 is the renal vein	5 is the ureter
E	4 is the renal vein	5 is the ureter
F	4 is the renal artery	5 is the urethra

2   Element X has the electronic structure 2, 8, 3.

Which of the following statements about this element are correct?

    1   The element is in Group 12, Period 3 of the Periodic Table.

    2   The element reacts with oxygen to form a compound with the formula X_2O_3.

    3   The element reacts with bromine to form a compound with the formula XBr_3.

    4   The atomic number of the element is 13.

    5   The element is an alkali metal.

A   1 and 5 only

B   2 and 3 only

C   2 and 5 only

D   3 and 4 only

E   1, 4 and 5 only

F   2, 3 and 4 only

3 A student carries out an experiment to determine the density of the material from which two identical solid objects are made. She uses a balance and a measuring cylinder containing a fixed volume of liquid. The diagrams show different stages of her experiment, with some of the readings on the balance and some on the measuring cylinder.
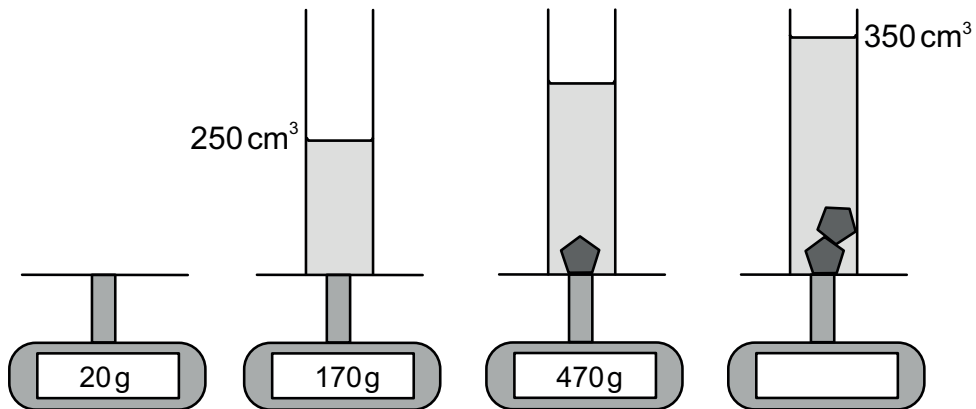
Which calculation should be used to determine the density of the material from which the objects are made?

A $\dfrac{280}{50}$ g/cm^3

B $\dfrac{280}{300}$ g/cm^3

C $\dfrac{280}{350}$ g/cm^3

D $\dfrac{300}{50}$ g/cm^3

E $\dfrac{300}{100}$ g/cm^3

F $\dfrac{600}{350}$ g/cm^3

G $\dfrac{750}{350}$ g/cm^3

H $\dfrac{770}{350}$ g/cm^3

4   A straight line passes through the points P $(-3,\ 3)$ and Q $(6,\ 9)$.

Which one of the following is an equation of a straight line which is parallel to PQ?

A $y = \dfrac{2x}{3} - 3$
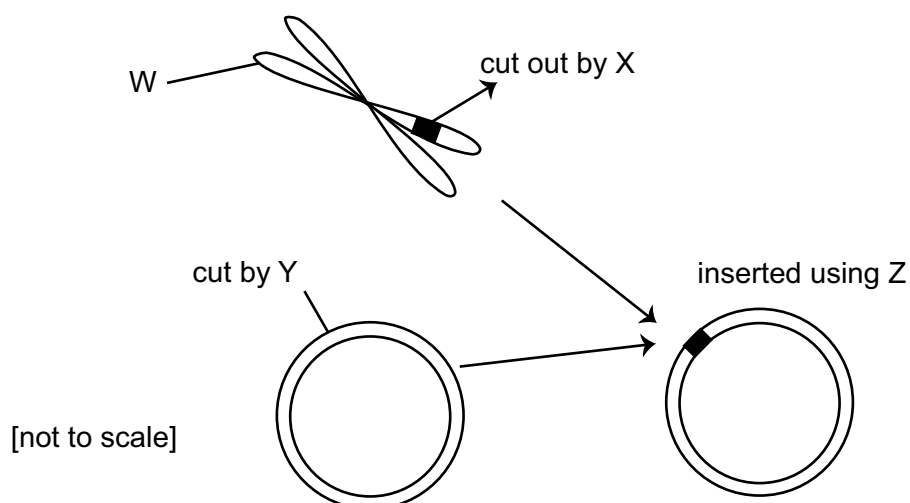
B $y = \dfrac{3x}{2} - 8$

C $y = \dfrac{x}{4} - \dfrac{1}{2}$

D $y = \dfrac{x}{2} - 2$

E $y = 2x - 11$

F $y = 4x - 23$

5 The diagram shows some of the stages of how a length of DNA can be removed from one organism and introduced into another organism.

cut out by X

W

cut by Y

inserted using Z

[not to scale]

Which row is correct?

	W is a	*X is a*	*Y is a*	*Z is a*
A	chromosome	restriction enzyme	restriction enzyme	restriction enzyme
B	chromosome	restriction enzyme	restriction enzyme	ligase
C	chromosome	ligase	ligase	ligase
D	gene	ligase	restriction enzyme	ligase
E	gene	ligase	ligase	restriction enzyme
F	gene	restriction enzyme	ligase	restriction enzyme

6 Which one of the following mixtures could **not** be separated using the technique given?

	mixture	*separating technique*
A	calcium carbonate and water	evaporation
B	pentane and octane	fractional distillation
C	silicon dioxide and water	filtration
D	sodium chloride and water	distillation
E	ethanol and water	separating funnel

[Turn over

7 Nickel has an atomic number of 28. The mass numbers of four of its isotopes are 58, 60, 61 and 62.

Below are three statements about these isotopes of nickel.

    1 All of them have the same chemical properties.

    2 All of them have nuclei containing 28 protons.

    3 One of them has a nucleus that contains 62 neutrons.

Which statement(s) is/are correct?

A 1 only

B 2 only

C 3 only

D 1 and 2 only

E 1 and 3 only

F 2 and 3 only

G 1, 2 and 3

H none of them

8 The mean mass of a group of N people is 75 kg.

Jim, Karen and Leroy join this group, without anyone leaving; the new mean mass is 78 kg.

The mean mass of Jim, Karen and Leroy is 90 kg.

What is the value of N?

A 4

B 12

C 15

D 30

E 48

F 90

9 The following statements are features of an enzyme from a healthy human.

    1   It works at an optimum pH below 4.

    2   It digests a substrate into amino acids.

    3   It works at an optimum temperature of approximately $37\,°C$.

Which enzyme has these features?

A amylase in the mouth

B amylase from the pancreas

C lipase in the mouth

D lipase from the pancreas

E protease from the small intestine

F protease from the stomach

10 Mohr's Salt is a common laboratory reagent. Use the information of the most abundant isotopes below to calculate the formula mass, M_r, of the hydrated salt.

Formula of Mohr's Salt: $(NH_4)_2Fe(SO_4)_2.6H_2O$

Most abundant isotopes: $^{1}_{1}H$, $^{14}_{7}N$, $^{16}_{8}O$, $^{32}_{16}S$, $^{56}_{26}Fe$

A 144

B 204

C 284

D 360

E 374

F 392

11 An AC voltage is induced in a coil of wire when it is rotated in a magnetic field.

This voltage can be displayed on the screen of an instrument called an oscilloscope, which shows the variation of the induced voltage on the *y*-axis plotted against time on the *x*-axis.

The oscilloscope trace below is the result of rotating a coil at a constant speed in a uniform magnetic field.
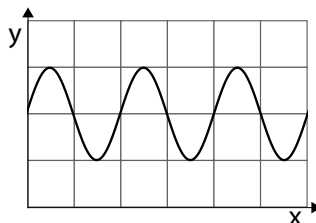
Which one of the following traces would result from rotating the coil at a faster constant speed, whilst keeping all other conditions unchanged? (The scales on the axes do not change.)

A

B

C

D

E
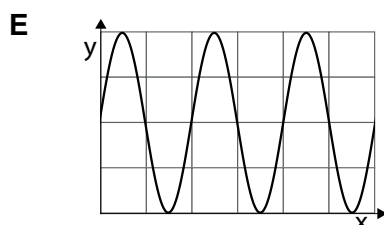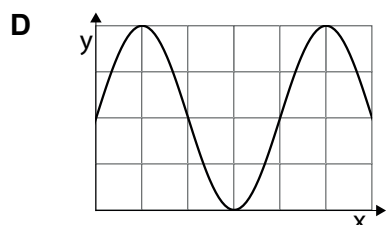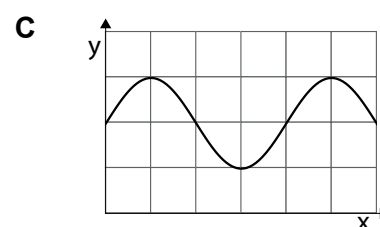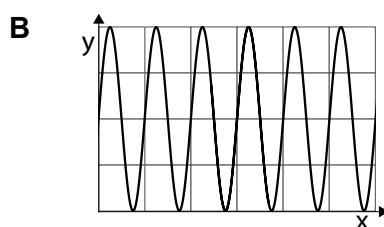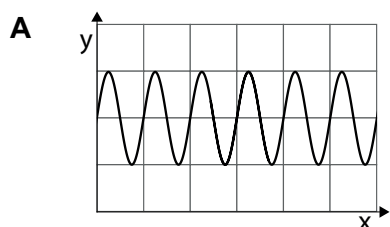
12 The diagram represents the circular cross-section of an artery with external diameter d of 1.6 cm. The thickness t of the artery wall is 1 mm.

$t = 1$ mm

[not to scale]

$d = 1.6$ cm
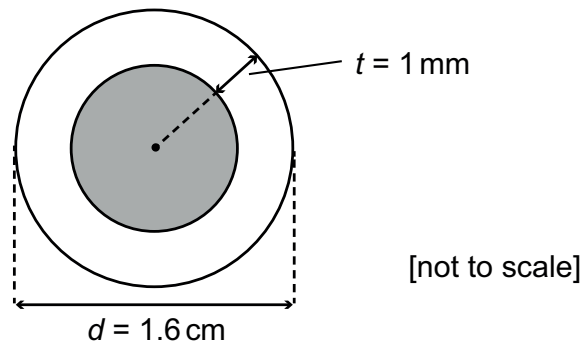
What is the internal cross-sectional area of the artery (shaded in the diagram)?

A 0.36π mm^2

B 14π mm^2

C 15π mm^2

D 49π mm^2

E 225π mm^2

13 Which of the following molecules are involved in **both** aerobic and anaerobic respiration in a healthy human?

1 carbon dioxide

2 glucose

3 lactic acid

A 1 only

B 2 only

C 1 and 2 only

D 1 and 3 only

E 2 and 3 only

F 1, 2 and 3

14 Identify the correct products of electrolysis of the following electrolytes.

	electrolyte being electrolysed	product at positive inert electrode (anode)	product at negative inert electrode (cathode)
A	aqueous calcium bromide	bromine	calcium
B	aqueous copper nitrate	nitrogen	copper
C	aqueous potassium sulfate	oxygen	hydrogen
D	molten aluminium oxide	aluminium	oxygen
E	molten sodium chloride	chlorine	hydrogen

15 The diagram represents a satellite communication link between two points on Earth. The distances between the transmitting station, the satellite and the receiving station are shown.

The frequency of the waves used for the link can be taken as 1.5×10^{10} Hz, and the speed of light as 3.0×10^8 m/s.
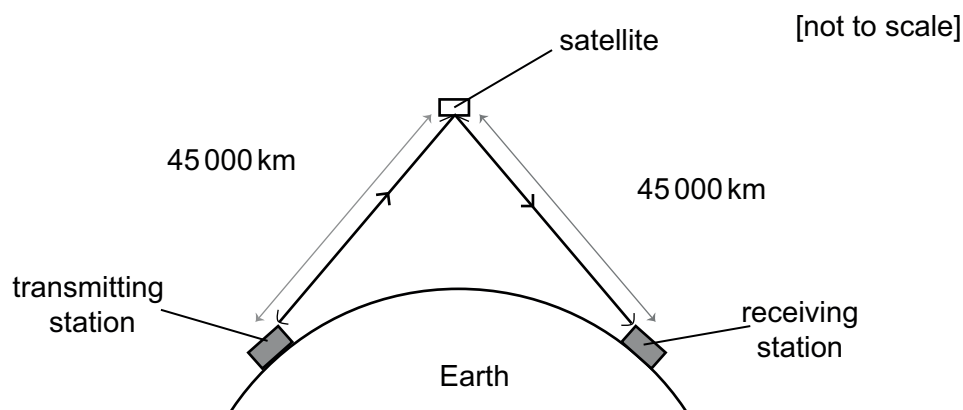
What type of wave is used in such a link, and what is the time delay between a signal being transmitted and then being received at the receiving station?

	type of wave	time delay (s)
A	microwave	0.0015
B	microwave	0.0030
C	microwave	0.15
D	microwave	0.30
E	ultraviolet	0.0015
F	ultraviolet	0.0030
G	ultraviolet	0.15
H	ultraviolet	0.30

16 The diagram shows a quadrilateral PQRS.
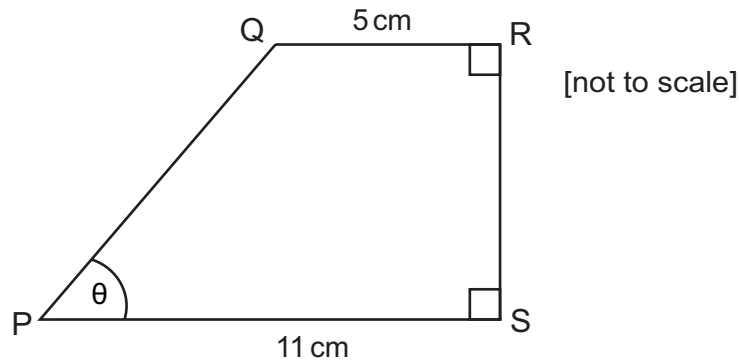
Given that $\tan \theta = \dfrac{4}{3}$, what is the area of the quadrilateral PQRS?

A 34 cm²

B 36 cm²

C 64 cm²

D 88 cm²

E 112 cm²

17 Which of the following statements could describe the result of a single mutation of a gene coding for a protease enzyme in a fertilised human egg cell?

1 A new allele is formed coding for a protease enzyme that works more efficiently.

2 A new allele is formed coding for a protease enzyme that works less efficiently.

3 A new allele is formed coding for a non-functional protein that has no effect on the cell.

4 A new allele is formed coding for a non-functional protein that has a negative effect on the cell.

A 1 only

B 2 only

C 1 and 2 only

D 3 and 4 only

E 1, 2 and 3 only

F 1, 2 and 4 only

G 1, 2, 3 and 4

18 What volume of a $0.10\,mol\,dm^{-3}$ solution of NaOH is needed to neutralise $30\,cm^3$ of a $0.20\,mol\,dm^{-3}$ aqueous solution of a diprotic acid?

 A $7.5\,cm^3$

 B $15\,cm^3$

 C $30\,cm^3$

 D $60\,cm^3$

 E $120\,cm^3$

19 A defibrillator provides an electric shock to a heart to restore its normal rhythm. The energy to do this is 125 J, at a steady voltage of 500 V, for a time of 10 milliseconds.

 What is the current during this process?

 A 2.5 mA

 B 25 mA

 C 2.5 A

 D 25 A

 E 6250 A

 F 6250 kA

20 Rearrange the formula $\dfrac{a}{b} = \dfrac{c}{d} + \dfrac{e}{f}$ to make f the subject.

 A $f = \dfrac{bce - ade}{ac}$

 B $f = \dfrac{bc + be - ad}{a}$

 C $f = \dfrac{bde}{ad - bc}$

 D $f = \dfrac{bcd}{ad - be}$

 **E** $f = \dfrac{bc + be}{ad}$

[Turn over

21 Which statements describe a role of mitosis?

> **1** asexual reproduction
>
> **2** growth of a cell
>
> **3** repair of cells
>
> **4** stem cell division

A 1 and 4 only

B 1, 2 and 3 only

C 1, 2 and 4 only

D 1, 3 and 4 only

E 2, 3 and 4 only

F 1, 2, 3 and 4

22 Calcium carbonate reacts with hydrochloric acid. The reaction gives off carbon dioxide gas.

Line **X** on the graph shows the volume of carbon dioxide formed against time when $100 \, cm^3$ of $1.0 \, mol \, dm^{-3}$ of hydrochloric acid reacts with calcium carbonate chips at $20 °C$. There was an excess of calcium carbonate chips.

$$CaCO_3 \; + \; 2HCl \; \rightarrow \; CaCl_2 \; + \; CO_2 \; + \; H_2O(l)$$
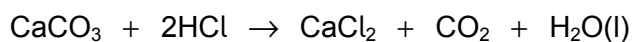
Which line best represents the volume of carbon dioxide formed against time when the reaction is repeated with $50 \, cm^3$ of $2.0 \, mol \, dm^{-3}$ of hydrochloric acid reacting with excess calcium carbonate chips at $20 °C$?
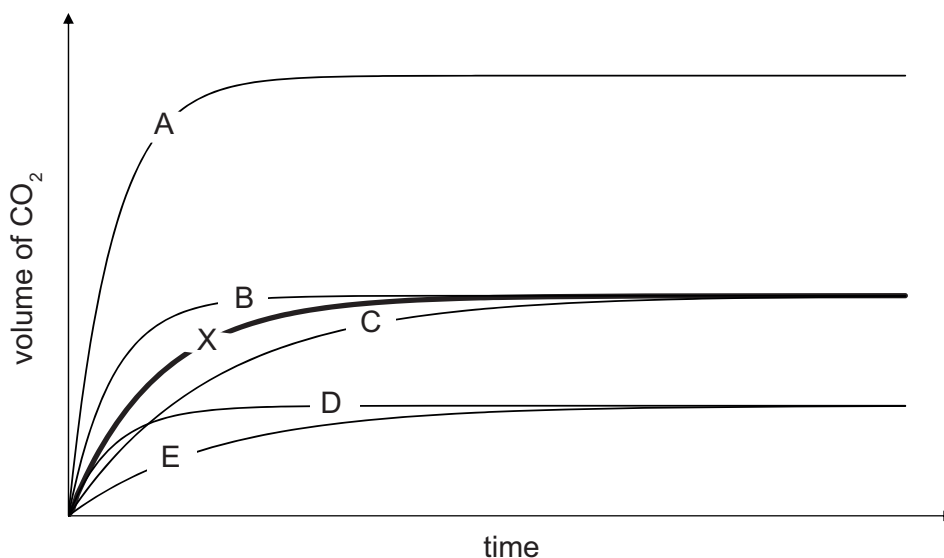
A line A

B line B

C line C

D line D

E line E

23 An object that has a weight of 15 N on Earth is taken to a planet where it has a weight of 3.0 N. The planet has no atmosphere.

Which line in the table correctly shows the mass of the object on the planet, and the kinetic energy it gains after falling from rest near the surface of the planet through a vertical distance of 10 m?

(Take the gravitational field strength g on Earth to be 10 N / kg.)

	mass of object on planet (kg)	kinetic energy after falling 10 m on planet (J)
A	0.30	0.60
B	0.30	6.0
C	0.30	30
D	1.5	15
E	1.5	30
F	1.5	150

24 Some blood is found at a crime scene. The police know that it belongs to the **one** criminal involved.

A person's red blood cells can have type A antigens, type B antigens, both types or neither type.

In a population:

45% of people have type A antigens but not type B

9% of people have type B antigens but not type A

43% of people have neither type of antigen

3% of people have both types of antigen

An antibody test shows that there are type B antigens present in the red blood cells at the crime scene.

What is the probability that the criminal's red blood cells have **both** type A and type B antigens?
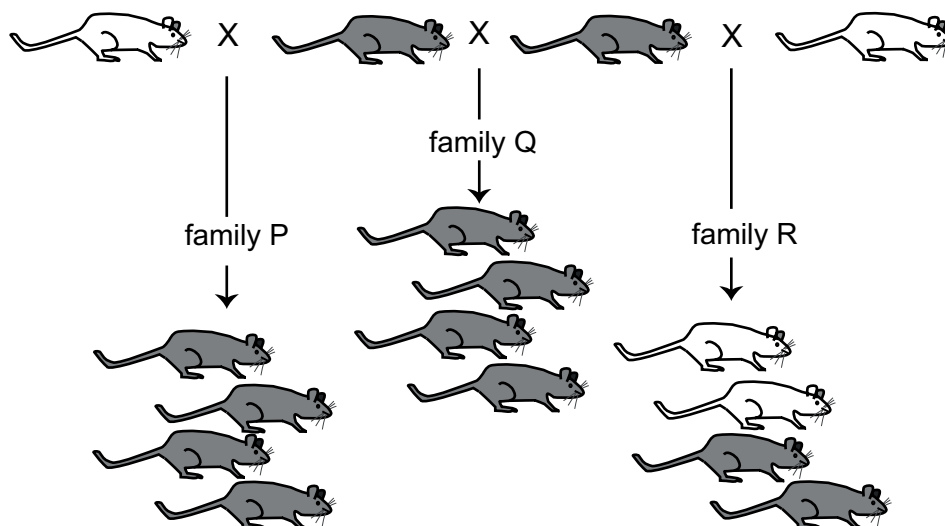
A $\dfrac{3}{100}$

B $\dfrac{1}{16}$

C $\dfrac{3}{25}$

D $\dfrac{1}{4}$

E $\dfrac{3}{4}$

25 An experiment was carried out to investigate a gene for coat colour in mice.
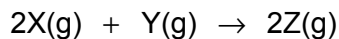
The diagram shows the results of **three** crosses between different mice, producing three different families, P, Q and R.


What is the maximum possible number of heterozygous mice shown in the diagram?

A 2

B 3

C 4

D 5

E 6

F 7

G 8

H 12

26 The gases X and Y react with each other to produce gas Z according to the equation:

$$2X(g) + Y(g) \rightarrow 2Z(g)$$

$100\,cm^3$ of X was mixed with $10\,cm^3$ of Y, in a freely moving gas syringe sealed with a rubber cap. The reaction went to completion. All volumes were measured at the same temperature and pressure.

gas syringe

rubber cap
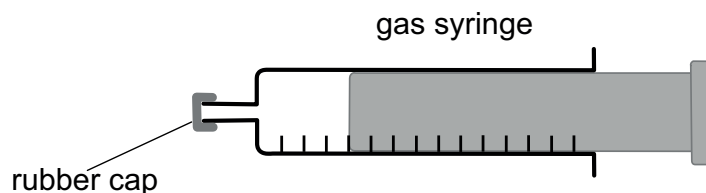
What is the final volume of gas in the syringe?

A $20\,cm^3$

B $55\,cm^3$

C $80\,cm^3$

D $100\,cm^3$

E $110\,cm^3$

F $120\,cm^3$

27 Light travels through glass at a speed which is $\dfrac{2}{3}$ of its speed through air.

Light travels through water at a speed which is $\dfrac{3}{4}$ of its speed through air.

A ray of light has a wavelength of $360\,nm$ when travelling through water.

What is the wavelength of this ray of light when travelling through glass?

A $180\,nm$

B $240\,nm$

C $320\,nm$

D $330\,nm$

E $390\,nm$

F $540\,nm$

G $720\,nm$

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